Industry Perspective on PCD Research

- GE Aviation -

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GE Aviation Perspective on PCD Research

GEA Propulsion Controls Research Focus:

- Meeting customers key requirements
 - Cost, Weight and Reliability Traditional values
 - Functionality More and more all the time....
 - Cost of Ownership Key metric for customers
- Furthering the goals of the business
- Advancing your business's competitive position

Evolution or Revolution, What's Your Goal?

- Corporate Technology Issues
 - Game changer or 0.05% better/lighter/cheaper
 - Industry collaboration or just your business
 - Competitive edge required, but \$\$ costs constrain options
 - DECWG, PIWG HT Electronics and Test Instrumentation
 - Goes after the cost issue and promotes progress
 - Automotive AUTOSAR (automotive common software standard)
 - Universities, NASA, Government Goal alignment to conserve \$\$



GE Aviation Perspective on PCD Research Industry Trends

Distributed Architectures

- System complexities are driving architectural change
- Driven partly by complex FADEC electrical obsolescence issues
 - Easier to recover with smaller, simpler modules
- Parallels other industries, automotive, industrial
 - > Remember that big ECU under the dash in your 1980's car?
- High temperature electronics with long life capability required

Sensing Systems

- Always more engine data required
- Complex I/O, extreme parameters, volume limitations, wire count, etc.
- Adds to electrical system I/O, system complexity, fault detection/isolation/accommodation

Diagnostics and Prognostics

- Great New Frontier of technical innovation
 - Big payoff for customers, Cost of Ownership opportunity
- Real time processing, complex algorithms and models, huge data sets

Multicore processors, certification complexity, memory, bus data

GE Aviation Perspective on PCD Research Industry Trends

Adjacencies, what have they done?

- Biggest controls business in the world is automotive
- Automotive industry embraced distributed systems in 1980's
- Same reasons as Aviation, but easier environmental challenges
 - At least up until now....new cars have temp. challenges too
- Business situation is different, but instructive anyway
 - Create industry collaboration AUTOSAR (Similar to DECWG)
 - Open source software, standardize hardware
- Share the pain on building blocks, compete on implementation

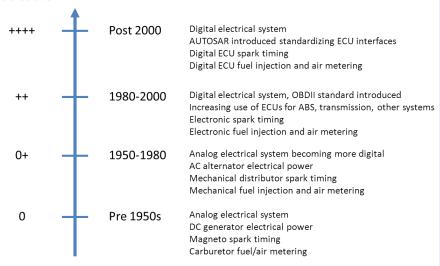
- Excerpt from AUTOSAR Web Site -

AUTOSAR (AUTomotive Open System ARchitecture) is an open and standardized automotive software architecture, jointly developed by automobile manufacturers, suppliers and tool developers.

- ¬ AUTOSAR paves the way for innovative electronic systems that further improve performance, safety and environmental friendliness
- •is a strong global partnership that creates one common standard: "Cooperate on standards, compete on implementation"
- •is a key enabling technology to **manage the growing electrics/electronics complexity**. It aims to be prepared for the upcoming technologies and to improve cost-efficiency without making any compromise with respect to quality
- •facilitates the exchange and update of software and hardware over the service life of the vehicle

Evolution of Automotive Electrical Systems

ECU Count

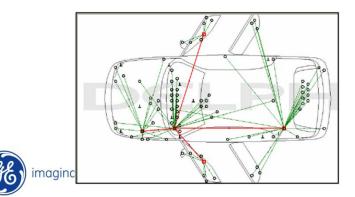


Design Issues Driving Creation of AUTOSAR Architecture

Challenges pre-AUTOSAR	Solution post-AUTOSAR
Microcontroller obsolescence	Microcontroller abstraction separates HW and SW certification
Throughput limitations	
Reusing AS modules on new	
programs	Virtual Functional Bus used for
Relocating AS modules to different ECUs/DCMs	AS - OS communication
High cost to make small SW changes	Standardized communication interface
Difficulty adapting similar administrative functions between OEMs	

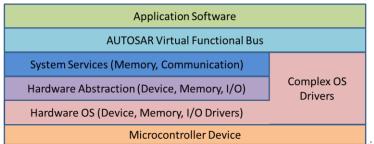
Electrical/Electronics (E/E) Architecture Optimization Overview

- Vehicles use distributed architecture typically with 5-8 ECUs
- Most functions located on closest ECU under old process
- New E/E architecture process determines optimal location of functions
- E/E optimization goal to reduce system cost, mass, wire count



AUTOSAR Layered Software Architecture Overview

- Standardized architecture jointly developed by manufacturers and suppliers
- Virtual Functional Bus separates AS and OS enabling:
 - AS module reuse
 - Detection and debug interface issues
 - Reduction of SW version proliferation
 - Standardized tool development



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Automotive Engine Control Module (ECM) Overview

- Similar functionality to FADEC at decreased cost
- Distributed E/E and AUTOSAR architecture reduce obsolescence risk and NPI cost

Feature overview:

- Single channel 80-200MHz 32 bit processor
- 3Mb flash memory, 16kb program memory, 512kb RAM
- CAN, LIN, RS232 serial busses
- Rated for -40°C to 105°C case temperature
- Available with vibe isolators for engine installation



Maximize return on technology investment \$\$

- Automotive collaborates on building blocks
 - Share expense across industry
 - Similar to DECWG
- OEM's focus on system design, optimization
- Limited IR&D funds spent on technology, not building blocks

Automotive hardware functionality similar to Aviation

- Distributed systems, reduced wire count
- Smart components, localized intelligence
- AUTOSAR interface allows same ECM to be used in multiple locations
- Obsolescence resistant architectures
- Minimizes # of parts, maximizes product volume

Remote Automotive Actuators with Diagnostic Capability

- VG actuators have integrated position sensing electronics
- CAN control reduces wire count (4 wires per channel)
- OBDII allows improved fault isolation and annunciation capability
- Rated for -40°C to 105°C at board with air cooling, higher with fluid cooling



GE Aviation Perspective on PCD Research

Summary

- Complexity of systems is driving a new approach to control system design
 - Distributed electrical/electronic systems
- High temperature electronics are a keystone technology
 - Simplifies new system implementation
 - Facilitates new levels of capability beyond today
 - accuracy, fault detect/isolation, functionality
- Industry collaboration can drive efficiency into our technology efforts
 - > AUTOSAR collaboration is a good case study
 - Aerospace avionics, FACE, <u>Future Airborne Capability Environment</u>
 - DECWG, PIWG are a great start

Question: What else should our industry do to accelerate technology adaptation?



